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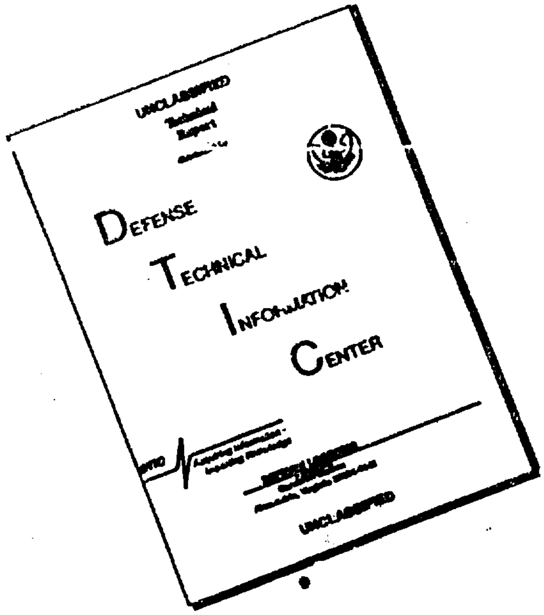

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FOREWORD

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LETTER TO THE EDITOR

TRANSISTORIZED ELECTROSLEEP GENERATOR

I have followed your publications on electrosleep and was especially interested in the circuit of Mr. Arsen Iwanovsky's tube-operated electrosleep generator based on a Soviet prototype. On the basis of this circuit, I have designed and built a transistorized electrosleep device (patent pending).

The circuit (see Fig. 1) consists of five basic stages. The first stage is a multivibrator with a unijunction transistor to develop a sawtooth wave, and a second transistor which converts the sawtooth wave into a square wave with the same repetition rate. By switching capacitors and varying the 100-kohm resistance in this circuit, frequencies can be selected in the 1.8—18.5-Hz and 19—198.9-Hz ranges.

The second stage is an emitter follower for matching impedance between the first and third stages. The third stage is a one-shot multivibrator. A 10-kohm potentiometer in this circuit provides the adjustment necessary to set the pulse width. Access to this adjustment is restricted, so that once the best pulse width is established the adjustment will not be disturbed. Experience has shown that the optimum pulse-width value is one millisecond.

The fourth stage is an amplifier and inverter circuit. The final stage contains an emitter follower circuit for matching the impedances of the instrument and the human body. It also contains a potentiometer for controlling output current, which is monitored by a microammeter. Another feature found in the final stage is a 500-ohm potentiometer shunted by a 1000-μF capacitor to provide a d-c bias.

In the future, I intend to miniaturize my circuit to produce a device which would fit under the lining of a pillow and which could be powered by miniature long-life batteries.

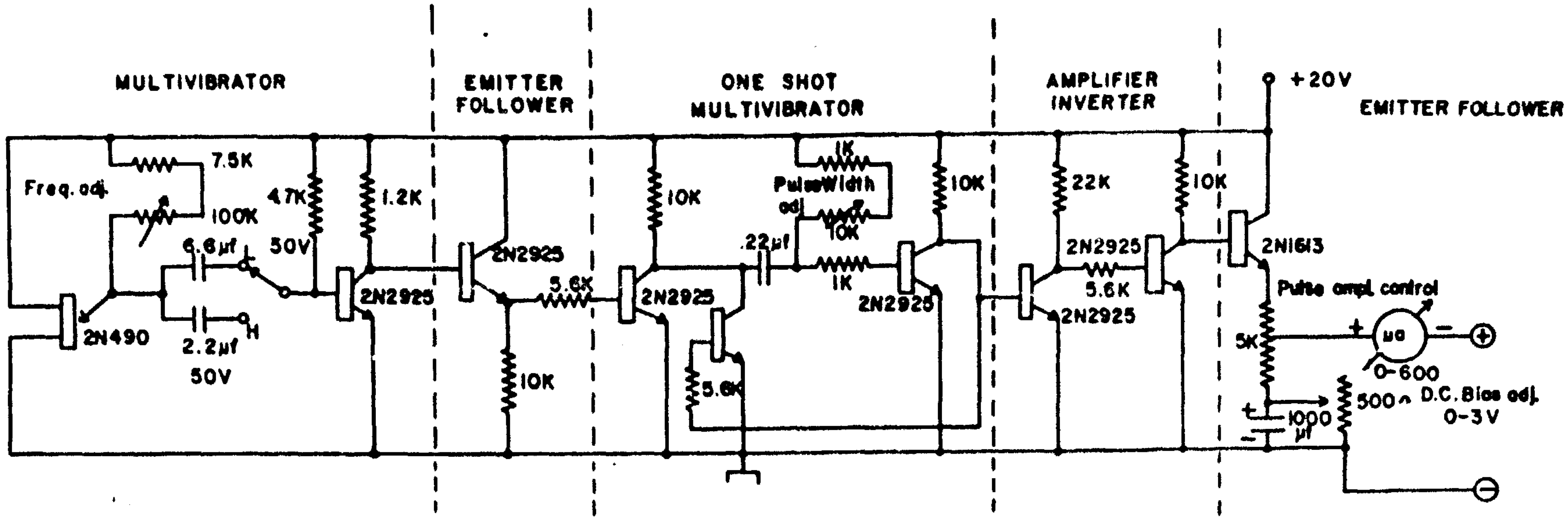

Fig. 1. Circuit diagram of transistorized electrosleep generator.

I would like to point out that this instrument has been developed strictly for experimental evaluation and that its electrical output is equal to or less than that of other electrosleep instruments which have been proven safe when used by a qualified operator.

In conclusion, I would like to express my special thanks to Mr. Arsen Iwanovsky of the Library of Congress, who provided the technical information on electrical output requirements and who has collected worldwide information on experiments and clinical applications of electrosleep and electroanesthesia. I would further like to thank Mr. Malcolm Minor of the Bunker-Ramo Corporation, who assisted me in the packaging design.

Maksim Aleksandrov

PAPERS

THE SOYUZ-3 MISSION

by Boris Mandrovsky

SUMMARY: Data published in the Soviet press between 27 October and 6 November on the successful flight of the Soyuz-3 are presented. Information is included on maneuvers in orbit, rendezvous with Soyuz-2, aerodynamic descent, Soviet comments on design, systems, and capabilities of the Soyuz spacecraft, and the biomedical aspects of the Soyuz-3 flight.

On 26 October 1968 the Soyuz-3 spacecraft was launched from the Baykonur cosmodrome. This was the first successful Soviet manned spaceflight since Leonov's EVA on Voshkhod-2 3 1/2 years ago. Beregovoy was the only cosmonaut on board.

Cosmonaut Beregovoy

Georgiy Timofeyevich Beregovoy, Colonel in the Soviet Air Force and Hero of the Soviet Union, began his career as a combat pilot prior to World War II. From 1948 to 1964 he worked as a test pilot. He is a relative latecomer to the Soviet manned spaceflight program, having begun his training in 1964 [1, 2, 9, 13].

Dr. O. G. Gazenko stated that Beregovoy, despite his 47 years, was well trained and conditioned to withstand the acceleration stress during the powered section of the flight. [52, 55]. Beregovoy's training included centrifugation, echoless chambers, "rotor" training, thermochamber, vibrostand, parachute jumps, parabolic short-term weightlessness, and work in spacecraft simulators [11]. Beregovoy spent many hours in spacecraft simulators but only two periods of several hours each in the Soyuz-3 itself before the flight [7]. Professor V. V. Parin stated that Beregovoy was selected for the Soyuz-3 mission because he was an experienced test pilot [22, 23].

The Soyuz-3 Mission Objectives

The main purpose of the Soyuz-3 mission, according to K. P. Feoktistov (the scientist who flew on the three-man Voskhod-1 mission), was to check out the Soyuz-3 systems and equipment. More specifically, the mission involved the testing of the automatic approach equipment and manual-control procedures used for rendezvous with Soyuz-2 (an unmanned spacecraft which had been launched from Baykonur a day before Soyuz-3 went into orbit) [52, 54]. According to Academician B. N. Petrov, the rendezvous with the unmanned Soyuz-2 (a continuation of the docking maneuvers carried out by Kosmos 186-188 and Kosmos 212-213), was the highlight of the entire Soyuz-3 mission [15].

In addition to evaluating the performance of the Soyuz-3 and of its propulsion and control system during rendezvous with Soyuz-2 and during maneuvers in orbit, Beregovoy carried out an extensive program of scientific observations in space [42]. These tasks included: observation of stellar skies, of the daytime and twilight horizons of the Earth, and of the reflectivity of the surface of the Earth; photography and visual observation of the cloud and snow covers of the Earth; investigation of the luminescent particles which accompany spaceships; and investigation of the micrometeor hazard and of its effect on the ship and its systems [15, 18, 42]. In addition, Beregovoy served as a guinea pig in a study of the effects of spaceflight conditions on human work capacity and on the functions of the visual analyzer [29, 30].

The Soyuz-3 Spaceship

The Soyuz-3 spaceship is a new-generation space vehicle showing considerable advances over the Vostok and Voskhod types [43]. Beregovoy, upon his return, spoke of the Soyuz-3 enthusiastically as a wonderful piece of equipment of new design, capable of carrying out an extensive program of scientific experiments [49]. It is described as large and comfortable, consisting of two compartments in which the cosmonaut may work without a spacesuit [49]. The first of these is a control compartment, which during reentry also serves as a descent

module. The second is a rest and observation compartment, which Feoktistov referred to as the "orbital" compartment. The control compartment has three windows, while the rest and observation compartment has four. The total living space in these two compartments, which have a shirt sleeve environment, is 9 m^3 [52, 54].

Feoktistov explained that the orbital compartment (intended for rest and observation) contains equipment for scientific experiments, as well as part of the spaceship control and communications equipment. The control compartment contains controls for maneuvering in orbit, together with most of the spaceship control and communications equipment. It also contains the life support equipment. The control compartment has couches for the crew during lift-off. During reentry this compartment separates from the orbital compartment, and becomes the descent module [52, 54].

The Soyuz has an external thermal shield (to protect it from atmospheric friction during reentry), and an inner layer of thermal insulation (which also acts as a noise insulator). As a result of these devices, cabin atmosphere does not rise above 25 to 30 °C, even during reentry [52, 54].

In addition to the two compartments for use by cosmonauts, the Soyuz contains an instrument and equipment compartment. A hermetically sealed part of this compartment holds the main on-board equipment which is used during orbital flight. The nonsealed part contains liquid fuel rockets used during maneuvers in orbit and during reentry [52, 54]. There are two of these propulsion rockets, each with a 400-kg thrust. They enable the Soyuz to maneuver to altitudes of 1300 km [52, 54].

Academician Keldysh (President of the Academy of Sciences USSR) pointed out that Soyuz spacecraft are equipped with automatic equipment of the type used by Kosmos 186-188 and Kosmos 212-213 for rendezvous and docking purposes [53]. Keldysh went on to say that in addition to being capable of automatic docking (which was not performed during the Soyuz-3 mission), the Soyuz ships are designed for a whole series of maneuverable missions. He stressed, however, that the Soyuz craft are intended for orbital (not lunar) missions [57].

Soyuz-type spacecraft are designed for multiman crews [52, 57]. They have a more advanced type of life support equipment and are capable of extended, 30-day flights [22, 23, 52, 54].

<u>The First Day in Space (26 Oct 68)</u>

At 11:34 h,* 26 Oct 68, the Soyuz-3 spacecraft was launched from the Baykonur Cosmodrome. TASS gave the orbit parameters as follows: period of revolution 88.6 min, apogee 225 km, perigee 205 km, and inclination 51° 40′ [1, 5, 8, 12].

The flight plan of the Soyuz-3 mission called for a rendezvous approach to the unmanned Soyuz-2 during Beregovoy's first orbit [6, 12, 43]. The unmanned Soyuz-2 had been placed into orbit on 25 Oct 58, with a period of revolution of 88.5 min, an apogee of 224 km, a perigee of 185 km, and an inclination of 51.7 [5, 6, 8, 12]. At the time that Soyuz-3 was placed into orbit, the Soyuz-2 was only a few km away. Their relative speed in respect to each other was 17 meters/sec [16].

The approach to Soyuz-2 was a two-stage affair [43]. Beregovoy sought out the "passive" Soyuz-2 by means of automatic on-board equipment (which included a computer) [16, 19, 43, 46]. This automatic equipment was described as being similar to that carried by the Kosmos series which made it possible for Kosmos 186-188 and Kosmos 212-213 to rendezvous and dock in orbit [16]. The automatic equipment brought the Soyuz-3 within 200 m of Soyuz-2 at, which time Beregovoy switched out the automatic equipment and took over manual control [16, 19, 43]. Manual control is carried out by means of two handles which actuate the reactive engines (rockets). One handle controls the speed of the ship, while the other rotates it about its center of gravity [16]. Beregovoy slowed down his spacecraft so that his relative motion in respect to Soyuz-2 was only a few tenths of a meter per second [16, 19], with a distance between the two spacecraft of only a few meters [52, 57]. In addition to using the automatic equipment for orientation, Beregovoy also performed independent orientation by the sun and using the manual controls [15, 18, 21, 46].

* All times mentioned in this paper refer to Moscow time.

By 18:45 h, 26 Oct 68, the Soyuz-3 had completed its fifth orbit. Cabin pressure was 760 mm Hg and the temperature was 17 °C [16, 8, 12]. From 19:18 h, 26 Oct, until 05:16 h, 27 Oct, the Soyuz-3 was out of the zone of radio visibility from the USSR. During this time, Beregovoy relaxed and slept in the observation and rest compartment [6, 8, 12].

The Second Day in Space (27 Oct 68)

After sleeping for 7 h, Beregovoy began his second day in space at 04:30 h. At 05:16 h, Beregovoy reported that he had slept well and that upon awakening he had performed physical exercises and breakfasted with appetite. The Soyuz-3 was now in its 13th orbit. The cabin pressure was 780 mm Hg, the temperature was 21 °C, and all systems were reported working perfectly [15, 18]. At 10:56 h, the Soyuz-3 completed its 16th orbit and Beregovoy reported that all tasks up to that time had been completed on schedule [15, 18].

During his second day in orbit, Beregovoy made another rendezvous with Soyuz-2, using the same automatic and manual techniques that he had employed on the previous day [15, 18, 21]. After the second rendezvous, both ships assumed new orbits. The new orbit parameters for Soyuz-2 were: period of revolution, 88.4 min; apogee, 231 km; perigee, 181 km; and inclination, 51.7°. The new orbit parameters for Soyuz-3 were: period of revolution, 88.6 min; apogee, 252 km; perigee, 179 km; and inclination, 51.7 [15, 18, 21].

By 18:50 h the Soyuz-2 had completed 38 orbits and the Soyuz-3 had completed 22 orbits. All systems on both ships were reported functioning perfectly. The Soyuz-3 cabin pressure was 785 mm Hg and the temperature was 23°C [15, 18, 21]. From 18:50 h, 27 Oct 68, to 04:48 h, 28 Oct 68, the Soyuz-3 was out of radio visibility of the USSR.

The Third Day in Space (28 Oct 68)

During this time Beregovoy slept [15, 18, 21]. At 04:48 h the Soyuz-3 reentered the radio visibility zone of the USSR. After 25 minutes of physical exercise and breakfast,

Beregovoy began his third day of work. He made radio and TV contact and reported that his condition was good and that all systems were functioning normally. The Soyuz-3 was in its 29th orbit [17, 18, 21].

At 10:25 h, the retrorockets on Soyuz-2 were fired, initiating the reentry and descent sequence. At 10:50 h the Soyuz-2 entered the denser layers of the atmosphere and began its controlled, aerodynamic descent. It completed the landing at a preassigned area in the USSR, employing a parachute and soft landing system [17, 18, 21].

By noon the Soyuz-3 had completed 33 orbits, and all systems were reported to be functioning normally. It was stated that temperature and pressure of the cabin were kept within the assigned limits (but they were not given!). Beregovoy continued his schedule of scientific observations [17, 18, 21]. At 12:15 h, during the 34th orbit, Beregovoy made a major TV broadcast, during which he explained the internal setup of the cabins and the control panels by means of which he accomplished the approach to Soyuz-2; he also demonstrated weightlessness for his viewers [17, 18, 21]. During the 36th orbit, he performed a number of maneuvers, using manual control and orientation. The orbital parameters were changed to: period of revolution, 88.6 min; apogee, 244 km; perigee, 199 km; and inclination, 51.7° [17, 18, 21]. By 18:30 h the Soyuz-3 was once more out of the radio visibility range. By 19:23 h the Soyuz-3 had completed 38 orbits [17, 18, 21].

At the end of the third day in space, temperature was in the 17—21°C range, and atmospheric pressure in the cabin held at about 300 mm Hg [24, 27]. At the operations center, the Head of the Ground Control Group stated that everything had been functioning perfectly; he added that they had never had such a perfect flight before [20].

The Fourth Day in Space (29 Oct 68)

At 03.45 h, Beregovoy began his fourth working day with breakfast and exercises. He reported that all systems were in good working order, that the cabin pressure was 777 mm Hg, and that the temperature was 18°C [24, 25]. At 07:28 h Beregovoy began his routine TV broadcast. By 11:10 h Soyuz-3 had

completed its 48th orbit [26].

During his 50th orbit (around noon), Beregovoy made another TV report. He reported on his scientific observations, demonstrated how food supplies and water are stored and used on board, and showed pictures of the observation and rest compartment [26, 27].

At 18:06 h, the Soyuz-3 left the radio visibility zone once more. By 19:03 h, the Soyuz-3 had completed its 54th orbit. Beregovoy had completed the assigned program for that day. All systems were in perfect working order. Cabin temperature and pressure were reported to be within normal limits (but again not specified!) [26, 27].

The Fifth Day in Space (30 Oct 68)

At 04:08 h, Beregovoy began his fifth and final working day. During the 61st orbit all systems were reported in good condition. Between 07:08 h and 07:20 h another routine radio communication was made. Beregovoy felt well and had retained his high work capacity. The temperature and pressure were once more reported to be within their assigned limits [34, 35].

Soyuz-3 was equipped with a new, reliable, multi-channel system for communication with ground stations [49]. The system operated on 15.008 and 20.008 MHz frequencies [1]. Beregovoy used the call name "Argon," and the control center used the call name "Zarya" [20]. At least part of the on-board power came from solar batteries [21]. The voice contact system was of sufficiently high fidelity that Beregovoy was able to recognize voices of his friends at ground stations [49]. Beregovoy stated that radio contact was reliable throughout the entire flight [52, 56].

Reentry, Descent, and Landing

In the early morning hours of 30 Oct 68, during his 61st orbit, Beregovoy received landing instructions from ground control. These instructions were repeated during the 62nd orbit [31, 37, 38]. Beregovoy initiated the reentry and descent sequence during his 64th orbit, while he was still over the Atlantic

near Africa [30, 31, 37]. Before switching on the automatic system which initiated the reentry and descent sequence, Beregovoy oriented his ship manually, attaining the proper attitude control [28, 36, 52, 56]. The automatic system actuated the retrorockets for 145 seconds, after which the Soyuz-3 began to descend from orbit [28, 36]. The descent module (control cabin) separated from the rest of the spaceship and assumed reentry attitude [28, 36].

When the reentry module entered the denser layers of the atmosphere, the controlled aerodynamic descent system went into operation [33, 36]. Feoktistov explained that the descent module uses a principal of controlled descent based on aerodynamic properties [52, 54]. The reactive engines (rockets) for the descent control are mounted externally on the descent module [52, 54]. The use of the aerodynamically controlled descent, Feoktistov stated, makes it possible to reduce the reentry stress to between 3 and 4 G (as compared with the 8—10 G experienced during ballistic descent) [52, 54]. For emergency purposes Soyuz-type spacecraft also have a ballistic descent capability [52, 54]. In addition to reducing the G-load, the controlled aerodynamic descent makes it possible to increase the accuracy of landing in a preassigned area [52, 54].

The phase of aerodynamically controlled descent was followed by parachute descent. The drogue parachute opened at an elevation of 9 km, followed in turn by the main parachute [52, 54]. In addition to the main parachute system, Soyuz-type spacecraft carry an auxiliary parachute system which is actuated in case the main parachute system fails [52, 54]. The parachute equipment systems are housed in a special container on the descent module [52, 54].

Final touchdown was made by a soft-landing system (solid fuel rockets) which was activated when the descent module was about 1 m above the ground [28, 33, 52, 54]. The soft-landing system rockets are mounted externally on the descent module [42, 54]. The control of the entire complex of devices which make up the reentry, descent, and landing systems is entirely automatic [52, 54].

At 10:25 h, 30 Oct 68, the Soyuz-3 landed at a pre-assigned area near the city of Karaganda [28, 29, 30, 31]. To facilitate the search and rescue, the descent module is equipped with special radio equipment which makes it possible to locate the spaceship during parachute descent as well as after landing [52, 54]. The Soyuz-3 was spotted by some of the local people while it was still descending by parachute, and for the first time it was possible to obtain a photograph of the parachute descent of a returning space vehicle [49]. The air rescue helicopter and the local residents arrived at the spaceship before Beregovoy had time to leave the descent module [40, 41, 56].

Post-Flight Events

After being greeted and congratulated by the local people and the air rescue team, Beregovoy was flown by helicopter to the local Search and Rescue Airport [31, 37, 45]. After washing up, shaving, eating, and receiving a preliminary medical examination, Beregovoy held a 15-minute press conference [41, 45]. From the Search and Rescue Airport Beregovoy was flown to the Cosmodrome, where a more detailed examination and debriefing was held [45]. From there he was flown by Il-18 to Moscow, where he was given a hero's welcome by top members of the Soviet government, his mother, wife, and children, and the other cosmonauts [45, 47].

For his performance in space, Beregovoy was awarded the title "Pilot-Cosmonaut of the USSR," the Order of Lenin, a second Gold Star of the Hero of the Soviet Union, and was promoted to Major General of Aviation [50, 51]. The Academy of Sciences USSR awarded him the coveted Tsiolkovskiy Metal [52, 53].

Beregovoy's Post-flight Statements

In his post-flight statements to the press, Beregovoy was enthusiastic about his spaceship. He stated that the Soyuz-3 is a new-generation vehicle with great possibilities, and that it differs from previous spacecraft not only in size and comfort but also in terms of new design principals and new spaceship systems [56]. Beregovoy was particularly enthusiastic about

the maneuverability of the Soyuz-3. He stated that his experience in space convinced him that both the automatic and the manual systems were highly reliable and effective [49, 56]. Beregovoy felt that the control panel indicators were well thought out and conveniently placed [52, 56].

Beregovoy stated that the lift-off was very smooth and that acceleration stress increased very gradually [40, 41]. He said that he was able to feel acceleration during about two-thirds of the powered sector of the flight. There was very little noise at lift-off. The roar increased gradually, but acceleration remained very smooth [40, 41]. He characterized weightlessness as an entirely new but pleasant sensation [32, 38, 45].

Beregovoy stated that during the reentry and descent sequence the automatic equipment worked very well [41]. The reentry stress was not too great (it was between 3 and 4 G) [40, 54]. Beregovoy was pressed against his acceleration couch but was still able to move his head, to make observations through the windows, and to carry on his work by making entries on tape [32, 39, 40, 41]. The descent module grounded so softly that Beregovoy was not even aware of the moment of touchdown [37, 39, 40]. When the parachutes began to drag the descent module along the ground, Beregovoy released the parachute system [32, 38].

Other Post-Flight Statements

Feoktistov stated that the primary purpose of the Soyuz-3 mission was to check out the automatic and manual rendezvous and approach equipment and procedures. He added that he felt the mission had been fully accomplished and the principles on which the new equipment was designed were fully justified as far as circumterrestrial missions are concerned [54].

TASS stated that the most important result of the Soyuz-3 flight was the development and perfection of procedures for rendezvous and maneuver in orbit using several systems of orientation and navigation control. They added that the two rendezvous missions with Soyuz-2 were a success [29, 30].

A specialist from the Control Center stated that communication and coordination between the Center and the cosmonaut were perfect, and that the mission was carried out according to program from start to finish [46].

The "chief designer" stated that he was satisfied with the mission, as were all teams who participated in the design of the mission. He added that the cosmonaut performed faultlessly at all stages of the flight [46].

The Chairman of the State Commission stated that all equipment worked perfectly and that the cosmonaut fulfilled all assigned tasks. The State Commission had no criticism to make [46].

Biomedical Aspects of the Soyuz-3 Flight

Biomedical specialists were concerned with the effects of spaceflight conditions on psychophysiological functions, especially those which can affect man's work capacity and psychosomatic state [42]. Medical monitoring included pulse and respiration frequency (pneumography), electrocardiography, and seismocardiography [18, 44]. For the two latter measurements, two types of electrodes have been developed: silver cup electrodes and porous latex plate electrodes saturated with "electrode paste" [44]. Biomedical data were transmitted to the ground control center, where they were analyzed by physicians and also processed by medical computers [44].

These basic medical data were supplemented by observation of the cosmonaut on TV and analysis of voice structure and speech tempo during radio contact [15, 21, 44]. In addition, Beregovoy performed certain functional tests, described his subjective feelings, evaluated his own ability to perform assigned tasks, investigated the work capacity of the visual analyzer, and reported on the condition of the skin of his face and hands [29, 30, 44]. Beregovoy's tasks also included the evaluation of techniques of working with various types of equipment and systems and conducting scientific experiments in space [42].

During lift-off and insertion into orbit, Beregovoy's pulse frequency rose to 102—103 per min, and his respiration rate was around 30 per min [25, 26, 52]. O. G. Gazenko observed that Beregovoy was well trained to withstand the acceleration stress during the powered sector of the flight, and that the above increases in heart and respiration rates were in keeping with the G-load [55]. During the first orbit Beregovoy's pulse rate dropped to 75 per min [24, 26]. During the first night his pulse rate was 56—60 per min and respiration was 16 per min. The following morning the pulse rate rose to 64—66 per min. The EKG picture was normal, showing that Beregovoy's adjustment to weightlessness was good [15]. During this 22nd orbit (when he was performing the second rendezvous with Soyuz-2) Beregovoy's pulse was 63 and respiration 16 per min [18].

For the remainder of the orbital flight Beregovoy's pulse varied from 52 to 67 and his respiration from 12 to 18 per min [17, 30]. After the first night his heart rate during sleep tended to remain around 52 per min [26]. Gazenko noted that after the first day Beregovoy's pulse and respiration frequency tended to correspond to the initial pre-flight levels. He added that no obvious deviations were noted on the EKG or seismocardiograph [52].

TASS reported that the analysis of biomedical data received from space indicated that Beregovoy had retained a high work capacity and had made a rapid adjustment to spaceflight conditions [25, 27]. In fact it took Beregovoy about a day to adjust to weightlessness [49]. Gazenko states that Beregovoy was fully aware of the onset of weightlessness and that weightlessness was accompanied by some lability in the pulse, but that after the first few orbits Beregovoy fully adjusted to flight conditions [52]. Reentry acceleration stress did not constitute a problem in the present case because the aerodynamic descent of Soyuz-3 reduced the reentry stress to between 3 and 4 G, instead of the usual 8 to 10 G experienced during ballistic descent [54].

Despite the recorded increase in solar activity during the Soyuz flight, radiation counters on Soyuz-3 indicated that the amount of cosmic and magnetically trapped radiation received by Beregovoy corresponded to the anticipated amount and did not exceed the safe limits [25, 55].

The work-rest schedule for the Soyuz-3 flight was designed with the idea of retaining Beregovoy's normal "terrestrial" rhythm of activity. Beregovoy's program in space followed the daily pattern he had observed on earth prior to his flight. Gazenko points out that this may well have contributed to Beregovoy's general sense of well-being. His sleep was satisfactory (although he did have to strap himself in to keep from awakening) [41, 55].

Throughout the flight Beregovoy had a good appetite [18]. His diet was sufficiently varied and included nutritious, vitamin-rich products (2800 kcal per diem) [55]. On the third day of flight, for example, his dinner consisted of chicken filet, cookies, cocoa with milk, and prunes [21].

Gazenko concluded his evaluation of the biomedical aspects of the Soyuz-3 flight by stating that execution of various work operations and physical exercise was accompanied by adequate physiological responses on the part of the organism. The retention of high work capacity enabled Beregovoy to carry out a heavy program of scientific and technical experiments [55].

A detailed post-flight clinical and physiological examination did not reveal any substantial deviations in the health of the cosmonaut. The only findings were a moderate temporary depression of some of the physiological indices of the cardiovascular system, weakly expressed indications of general fatigue, and a loss of about 2 kg in body weight [52, 55].

Life Support Systems and Cabin Environment

Professor V. V. Parin stated that the Soyuz-3 had advanced systems of life support capable of more extended flights [22, 23]. Feoktistov indicated that the life support systems of the Soyuz spacecraft provided a shirt-sleeve environment and

had a 30-day capability [52, 54]. O. G. Gazenko pointed out that one of the biomedical objectives of the Soyuz-3 flight was "to test the complex of life support systems under actual spaceflight conditions" [55].

The life support systems consisted of an atmosphere regenerating system and a thermoregulatory system. Atmosphere regeneration was based on stored alkali metals which generated O_2 and absorbed CO_2 and human gaseous metabolic products, and maintained a normal terrestrial environment. The thermoregulatory system maintained the required temperature and humidity. Excess humidity was removed from the atmosphere of the cabins by heat-exchanger and temperature-regulation units, which condensed and collected the moisture in special containers. Temperature and humidity could be adjusted by the cosmonaut for his comfort [58].

These new life support systems apparently provided a normal, sea level, terrestrial environment, as is evident from the TASS reports published during the flight of the Soyuz-3. Thus, at 18:45 h on 26 Oct 68, during the 5th orbit, the cabin pressure was 750 mm Hg and the temperature was 17°C [6, 8, 12]. On 27 Oct during the 13th orbit, the cabin pressure had risen to 760 mm Hg and the temperature to 21°C [15, 18]. By the 22nd orbit, at 18:50 h on 27 Oct, the cabin pressure was 785 mm Hg and the temperature was 23°C [21]. By noon of 28 Oct when Soyuz-3 had completed 33 orbits, TASS reported that the temperature and pressure were kept within the assigned limits, but they were no longer given [17, 18, 21].

In summarizing the first 3 days of spaceflight, TASS reported that all life support systems on the Soyuz-3 functioned normally and that during this period the atmospheric pressure of the cabin was around 800 mm Hg, while the temperature varied between 17 and 21°C [24, 25]. At 03:45 h on 29 Oct, when Beregovoy's fourth working day began, TASS reported the cabin pressure was 777 mm Hg and the temperature 18°C [24, 25]. By 19:03 h on 29 Oct, when Soyuz-3 had completed its 54th orbit, the temperature and pressure were reported as normal, but once more were not specified [26, 27]. During the

early morning broadcast of 30 Oct whick took place between 07:08 and 07:20 h, the temperature and pressure were once more reported to be within their assigned limits [34, 35].

Commenting on this subject during the 5 Nov press conference, Gazenko stated that the hygienic parameters of the cabin for the entire flight held within the assigned limits. The total pressure, he said, varied between 755 and 830 mm Hg, and the partial O_2 pressure hovered around 200 mm Hg. He stated that the temperature and humidity also remained in the comfort zone and that preliminary processing of the data indicated the effectiveness of the life support systems utilized during the Soyuz-3 flight [55]. This statement is supported by a space medicine specialist responsible for monitoring the Soyuz-3 flight, who stated that the life support systems functioned perfectly throughout the flight [46].

Indications of Future Events

Comments made by Soviet specialists after the Soyuz-3 flight have claried certain points in respect to future Soviet intentions for their space program.

Yuriy Marinin, the scientific commentator for the APN news agency, stated that the approach maneuver used by Beregovoy was preliminary training for docking [43]. Beregovoy stated that Soyuz-type spaceships are equipped for docking and that they can be expected to perform this operation in future flights [52]. Academician Keldysh stated flatly that docking between Soyuz-type spacecraft will take place in future missions [52, 57]. At the same time, Keldysh pointed out that the Soyuz spacecraft are intended for orbital and not lunar missions [57].

The "chief designer" stated that the success of the Soyuz-3 mission will help in organizing future spaceflights and that the Soyuz-type spacecraft will apparently be in use for a long time. Cosmonauts will work out flight procedures on these maneuverable ships which will become more complex with each mission [46].

In respect to the Soviet lunar missions, Academician Keldysh pointed out that there are many problems to be solved before man can go to the moon. He stated that until recently they did not even know whether a ship returning from the lunar area at escape velocity could make a safe reentry. However, he stated that Zond-5 returned safely [52, 57]. He added that the problem of sending man to the moon is also related to the radiation conditions in that area. He stated that if it becomes possible to get enough information concerning radiation in the lunar area with automatic equipment, and if it will be possible to reproduce these conditions in ground laboratories so that the effects can be tested on animals, it may even be possible to send man on lunar missions without preliminary animal missions [52, 57].

Commentary

Soviet reportage of the Soyuz-3 flight indicates that they regard it as an unqualified success which inaugurates a new era of comfortable, maneuverable, orbital spaceships capable of 30-day missions with multiman crews.

From the life sciences point of view, the most interesting features of the Soyuz-3 flight are the aerodynamic descent capability and the "new" life support systems.

By reducing the acceleration stress from 8—10 G to 3—4 G, the aerodynamic descent capability extends considerably the length of time that cosmonauts can be safely exposed to the deconditioning effects of weightlessness, thus providing a solution for a problem that has been of serious concern to Soviet space physiologists for some time.

The use of storage-type life support systems based on alkali metals was something of a disappointment, since these apparently use the principle on which the old Vostok and Voskhod were based, except that the Soyuz systems have been expanded to a 30-day capability.

However, in view of Parin's comment that the Soyuz systems were the product of "advanced biotechnology" and Gazenko's statement that one of the biomedical objectives was "to test the life support systems under actual spaceflight conditions," we should not exclude the possibility that, in addition to the conventional system, experimental life support systems (or parts of systems) may have been tested during the Soyuz-3 flight.

If so, it seems reasonable to assumre that the experimental system being tested was a physicochemical one. But since the Soviets tend to regard physicochemical systems as complementary (and not as alternatives), there is even a possibility that some of the links were biological ones, working symbiotically with physicochemical systems. In any case, reported changes in atmospheric pressure and temperature of the cabin deserve careful attention, since they may provide some indication as to whether or not experimental life support systems were tested in addition to the conventional one.

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SCIENCE'S SECOND MOST IMPORTANT ASSIGNMENT: HIGH-TEMPERATURE SUPERCONDUCTORS

by Zygmunt Litynski

SUMMARY: Soviet studies of superconductivity are briefly reviewed and possibilities of non-phonon mechanisms, which would account for high-temperature superconductors, are indicated as based on the most recent works by Geylikman and Ginzburg.

A general consensus is that humanity will start benefiting from a real technological breakthrough only when physics succeeds in solving the problems of thermonuclear power production. According to Soviet Academician V. L. Ginzburg of the Lebedev Institute, the greatest technological changes, next to thermonuclear reactors, will be achieved when room-temperature (> 273°K) superconductors become operational [1]. In spite of Ginzburg's cautious optimism, the prospects of such an achievement are generally considered remote. Another foremost Soviet superconductor expert, Ginzburg's colleague and collaborator A. A. Abrikosov, thinks that a tremendous growth in superconductor applications would occur even if materials with the T_c of liquid nitrogen (77°K) were discovered; however, he seems to share the prevailing pessimistic opinion of those scientists who, in accordance with present-day incomplete theories, set 20—30°K as the highest T_c attainable [2].

From Shubnikov to GLAG

Soviet science took an early and fruitful interest in superconductivity. Suffice to recall that it was the Russians (L. V. Shubnikov,* V. I. Khotkevich, Yu. D. Shepelev, Yu. N. Ryabinin) who, while studying the superconductivity of certain lead alloys in the mid-1930's, were the first to describe the characteristics of mixed-state high-field materials [3—6].

* L. V. Shubnikov died in 1937 during Stalin's purge.

In 1937, L. D. Landau predicted the structure of the intermediate state [7], which in 1947 was experimentally confirmed by A. G. Meshkovskiy and A. I. Shal'nikov [8]. In 1950, V. L. Ginzburg and L. D. Landau generalized the phenomenological theory of G. London and F. London [9]; their work made it possible to calculate the surface energy on the boundary between the normal and the superconducting phase, and to explain a number of other problems. Finally, in a series of important papers [10—24] published in the 1950's, V. L. Ginzburg, L. D. Landau, A. A. Abrikosov, and L. P. Gor'kov presented a new and now widely accepted interpretation of high-field superconductors, based on the concept of the main bulk of a high-field superconductor remaining superconducting up to an upper critical field determined by nonfilamentary electronic processes (the GLAG theory).

These were impressive contributions which alone seemed to promise forthcoming practical solutions. As is only too well-known, such solutions have not been worked out in the USSR, just as they have not been achieved in the West. The principal reason for this disappointing situation is that no material has yet been discovered which will remain superconducting at temperatures higher than 20°K. The question arises as to what facts Ginzburg, one of the world's top experts in the field, uses as the basis for his present expectations that a superconducting coil may be produced working at temperatures well above the present ones and perhaps even at or above room temperature.

In Search of a Non-Phonon Mechanism

It should be stressed that the Russians, along with everyone else, work on superconductivity within the broad framework of the 1957 Bardeen-Cooper-Schrieffer (BCS) theory. While conceding that with all its deficiencies the BCS theory remains the only one to explain the behavior of superconducting materials, they nevertheless do not accept all the BCS propositions. Thus, for example, the BCS theory states that the interelectron attractive forces causing superconductivity are due to phonon interactions, with the expression for the critical temperature taking

the form

$$T_c = 1,14 \quad \theta_D C^{-1/g}$$

where θ_D is the Debye temperature and g is the parameter characterizing the phonon-induced attractive forces between electrons. It is easily shown that the condition of lattice stability leads to the inequality

$$g < \frac{1}{2},$$

which means that, according to the theory, T_c must be approximately one order lower than the Debye temperature. Ginzburg's hope that room-temperature superconductors may one day be produced is based on his firmly expressed disbelief [1] that phonon interaction is the only mechanism which can produce electron pairing and thus the appearance of the superconducting state.

The possibility of formation of Cooper pairs by some non-phonon mechanism was first studied by S. V. Vonsovskiy and M. S. Svirskiy in 1958 [25]. One year later, A. I. Akhiyezer and I. Ya. Pomeranchuk showed that an additional interaction between electrons due to the exchange of spin waves leads to attraction for a pair of conduction electrons, if this pair is in a triplet state with zero-spin projection, and to repulsion in a singlet state [26]. Thus the authors demonstrated that this process can assist or hinder the occurrence of superconductivity, depending upon the spin-state of the pairing electrons.

The above pioneering studies, followed by other works performed by several Moscow, Leningrad, and Kiev superconductivity researchers, culminated in 1964 in an important paper by V. L. Ginzburg [27] in which he proposed a two-dimensional model of a high-temperature superconductor with the Cooper pairs formed due, not to phonons, but to excitons. Almost simultaneously, the *Physical Review* published W. A. Little's discussion of a new interaction mechanism of the electrons in molecular polymer chains, which could account for critical temperatures substantially higher than those due to phonon or magnon interactions [28]. Although some of Little's conclusions were contested in the West and in the USSR, his paper aroused great interest among Soviet students of high-temperature superconductivity, who are given to quoting it in all their recent papers on

this subject.

Geylikman's "Electronic" Model

In 1965 and 1966, B. T. Geylikman of the Moscow Physicotechnical Institute took up Little's idea and demonstrated that a purely electron mechanism, analogous to the one the American physicist ascribed to certain specifically conjugated chains of organic polymers and leading to similar high critical temperatures, can occur in ordinary three-dimensional metals [29, 30].

Geylikman examined two cases: 1) a pure metal of the transition group with two overlapping unfilled bands (s and d, or s and f), or an ordered alloy of two metals (a compound) with comparable concentrations of both compounds and a similar structure of the electron spectrum; and 2) an ordered alloy of a metal and a non-metal with comparable concentrations in which the electrons of the upper unfilled shell of the non-metal atom are not collective.

According to Geylikman's study, the first model deserves the most attention. Just as in the case of Little's polymer consisting of a "spine" and a series of side chains, the Coulomb repulsion between the first and second band of Geylikman's model leads to attraction between each electron pair in the first band and each pair in the second band. It can be said that the attractive forces are due to the interaction of the electrons in a given band with the charge-density oscillations of the other band.

The complete effective interaction between s- and d (f) electrons, unrestricted by the second approximation of the perturbation theory, can be found by the summation of plots in the so-called total-density approximation. In a model of loosely bound s-electrons and strongly bound d (f)-electrons which is simple but nevertheless sufficiently close to reality, the calculations are substantially simplified, indicating that attraction between the s-electrons outbalances repulsion. In the general case, the investigations become highly complex. However, in determined conditions and for real metals, Geylikman's calculations show that attraction can be stronger than repulsion, the

critical temperature for the superconducting state being on the order of 10^2—10^3°K. In the case of Geylikman's second model, conditions for the occurrence of superconductivity are more drastic and the critical temperatures are lower.

Ginzburg's Exciton Theory

The most recent major Soviet work on high-temperature superconductivity is that published in May 1968 by V. L. Ginzburg [31] based mainly on his own previous papers, but also on studies by other Soviet and Western researchers. As possible non-phonon mechanisms for the attraction between conduction electrons and thus for the onset of superconductivity, Ginzburg enumerates the exchange of spin waves (magnons), the interaction between electrons in different bands, and the interaction between conduction electrons and bound electrons. He even mentions such extreme concepts as that of nuclear forces being responsible for the superfluidity in neutron stars and that of weak interactions being a possible cause for the superfluidity of degenerate neutrino systems.

In practice, Ginzburg states, any attractive mechanism near the Fermi surface can be called "electronic" in the sense that it is the polarization of the electrons and not of the ions which plays the main part. However, because the term "electronic mechanism of superconductivity" can mean simply that a superconducting current is carried by electrons, in his last works Ginzburg has taken to using the term "exciton mechanism of superconductivity," having in mind electron-type excitons, and thus excluding not only phonon excitations but also those due to magnons and plasmons.

Ginzburg sees two main difficulties in using the exciton mechanism for superconductivity. The first, which he considers surmountable, is production of metals or some other conducting systems with a distinctly pronounced exciton spectrum. The second and much more serious drawback is that the interaction between the excitons and conduction electrons must be strong enough to overcome the omnipresent phonon interaction which leads to repulsion in precisely the frequency range of interest in this case.

His calculations show that the two conditions can be most likely satisfied in "unusual" conducting systems such as filamentary compounds, layer compounds and sandwiches of the dielectric—metal—dielectric type. Even though the prospects of obtaining sufficiently strong exciton interactions appear to be highest in filamentary or layer-type chemical compounds, the author thinks that sandwiches deserve particular attention because their composition and properties are more easily controlled.

Earlier Élan Slowed Down?

Ginzburg admits that there is no certainty that room-temperature superconductors or even materials with a liquid-nitrogen T_c will be produced. However, he complains bitterly that so little attention in terms of funding and scale of research is paid to the study of such high-temperature superconductor materials, while entire large scientific research institutes and laboratories are working full-speed on thermonuclear reactors. Ginzburg explains this disproportion by the application to the sciences of the same criteria which ladies use in determining the parameters of their miniskirts.

It should be noted that Ginzburg's complaint about the present lack of interest in such studies has been corroborated by other Soviet experts. In his recent review article on studies of new superconducting materials performed during the last 3—4 years, N. Ye. Alekseyevskiy [32] quotes only 20 Soviet works against 45 Western ones. Furthermore, at the last (1968) Moscow Conference of Soviet experts on superconducting materials [33], Ye. M. Savitskiy criticized his 250 colleagues particularly for their insufficient interest in research on superconductivity constants, for the slow advance in studies on single crystals of superconducting alloys and compounds, and for the non-development of unitary methods for measuring superconducting characteristics, or of standardized measuring instruments.

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DEVELOPMENT AND APPLICATIONS OF SOME SOVIET ALUMINUM ALLOYS

by Dimitri Vvedensky

Aluminum alloys are the most widely used group of light alloys in modern technology. For example, basic structures of numerous types of aircraft are made of aluminum alloys. Alloys for new types of aircraft must have a high strength, perform satisfactorily at elevated and subzero temperatures, withstand static loads and vibration, and be corrosion resistant and insensitive to unavoidable stress concentrators.

Most Soviet high-strength aluminum alloys have been developed on the basis of the aluminum-zinc-magnesium system. Although aluminum-zinc-magnesium alloys have a high strength of up to 50 kg/mm^2, they were initially of little use because of their high susceptibility to delayed fracture and stress corrosion and high sensitivity to stress concentrators. It is assumed that all these shortcomings are due to an intrinsic mechanism of aging in aluminum-zinc-magnesium alloys.

Aging of all age-hardenable aluminum alloys proceeds in three stages. The first, "zone-stage," is characterized by the formation of Guinier-Preston zones without any structural changes. In this state, the alloys have low yield strength, high ductility, high corrosion resistance, and low notch sensitivity (Fig. 1). The second, "phase-stage," is distinguished by the precipitation of particles of metastable phases at and near grain boundaries. The yield strength sharply increases, the elongation drops, the corrosion resistance reaches a minumum, and the notch sensitivity increases. In the third stage, coagulation of the precipitated particles occurs. The strength characteristics decrease somewhat, the ductility increases, and there is a sharp increase in corrosion resistance. The rupture strength, creep strength, and fatigue strength undergo no substantial changes during the three aging stages.

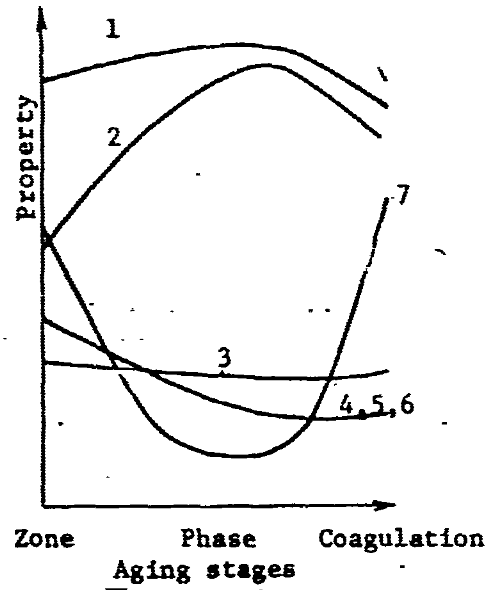

Fig. 1. Tensile strength (1), yield strength (2), reduction of area (3), elongation (4), impact strength of notched (5) and precracked (6) specimens, and corrosion resistance of aluminum alloys in various stages of aging [1].

Depending on the alloy composition, the transition from the zone-stage to the phase-stage of aging occurs at different temperatures and, in aging at the same temperature, after different time periods (Fig. 2). During this transition there are certain regions of mixed structure which contain both Guinier-Preston zones and precipitated particles of the metastable phases.

In aluminum-zinc-magnesium alloys, the transition may occur (provided sufficient time is allowed) at room temperature, at which the mixed structure is very brittle. Therefore, aluminum-zinc-magnesium-alloy parts in zone-stage condition become very susceptible to cold cracking after several months of service or storage. Even if the alloy is aged beyond the transition period to the phase-stage, it becomes brittle when exposed for prolonged periods of time to temperatures of 50--70° C, which are readily attained in sunlight.

Alloying with copper, modification with such structure stabilizers as chromium, manganese, or zirconium, and adjustment of aging conditions were the three methods used by Soviet

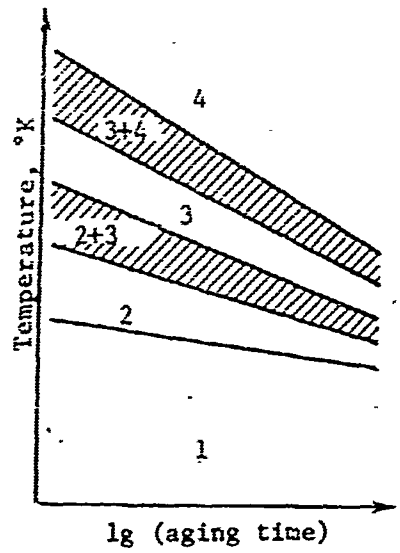

Fig. 2. Effect of temperature on the length of the period of transition from the zone-stage to the phase-stage of aging [1].

1 - Solid solution; 2 - Guinier-Preston zones; 3 - metastable phases; 4 - stable phases.

metallurgists to shift the time-temperature range of the transition from zone-stage to phase-stage of aging toward higher temperatures. The effort resulted in the development of two high-strength alloys, V95 and V96.

V95 alloy (5.0—7.0% zinc, 1.8—2.0% magnesium, 1.4—2.0% copper, 0.2—0.6% manganese, 0.1—0.25% chromium) has an average tensile strength of 55 kg/mm^2. V96 alloy (7.6—8.6% zinc, 2.5—3.2% magnesium, 2.2—2.8% copper, 0.2—0.5% manganese, 0.1—0.25% chromium) has a tensile strength of up to 70 kg/mm^2 [1, 2]. V95 alloy was used in the wing structures of TU-104 and TU-114 aircraft, and also in aircraft designed by O. K. Antonov. No failures have been reported. This success should be attributed to the Soviet school of thought according to which research on problems of metal science, such as development of new steels and alloys, usually is done in conjunction with the study of the behavior of these materials under various service conditions. For instance, V95 alloy was used in aircraft structures only after all the necessary specifications concerning the shape and design of the parts and their manufacture and assembly had been definitely established.

When O. K. Antonov began work on the "Antheus" [AN-22, a Soviet counterpart of the US C5A], whose main structure incorporated huge forgings weighing up to 5 tons, it was discovered that neither V95 nor V96 could be used for these forgings, owing to the presence of manganese and chromium stabilizers. Both these elements reduce flowability, which causes serious difficulties in casting large ingots; they also reduce hardenability, which brings about a sharply expressed anisotropy of mechanical properties and makes it necessary to use cold water for quenching after solution annealing, which in turn causes high internal stresses and distortion.

Extensive research revealed that the stability of the alloy structure and, consequently, of the mechanical properties could be ensured without stabilizers by balanced alloying and heat treatment. This led to the development of V93 alloy (6.5—7.5% zinc, 1.6—2.2% magnesium, 0.8—1.2% copper, 0.15—0.40% iron), in which chromium and manganese were replaced by a small amount of iron. The alloy has very good flowability and can be cast into ingots up to 1100 mm in diameter. Heavy sections can be quenched (after solution annealing) in very warm (70--80°C) water without risk of solid-solution decomposition, even in the central portions [2]. This greatly reduces distortion and internal stresses.

During this investigation it was also learned that if the phase (artificial) aging at 195°C is not done immediately after solution annealing, but is preceded by zone (natural) aging, it produces a structure with finely dispersed particles of metastable phases. The alloy in this condition has a high tensile strength, 50--53 kg/mm^2 in large forgings [2], at a satisfactory resistance to stress corrosion. The landing gear structure of "Antheus" was built from V93 forgings at a weight saving of 2 tons. The V93 alloy was also used in the Yak-40 airliner.

The wide use and the critical importance of the parts made of V93 alloy justified additional research aimed at improving its performance. S. I. Kishkina, for instance, found that the fatigue strength and corrosion resistance of V93 parts can be significantly improved by surface strain hardening.

Two other aluminum-zinc-magnesium alloys, 01915 and 01911, are presently being developed. Both have lower strength than V95, V96, or V93 alloys, but their susceptibility to cracking is low and they have satisfactory weldability.

More recently, a new family of heat-treatable high-strength aluminum-base alloys containing lithium has been introduced. The first such alloy, VAD23, contains 4.9—5.8% copper, 0.4—0.8% manganese, 1.0—1.4% lithium, and 0.1—0.25% cadmium. Cadmium plays a very important part in the alloy: it delays significantly the diffusion processes and reduces the size and increases the stability of precipitated particles of metastable phases. The alloy has a room-temperature tensile strength of 54 kg/mm^2 and a 1000-hr rupture strength of 14 kg/mm^2 at 200°C [2]. The high mechanical properties of VAD23 at room and elevated temperatures make it a very promising material for the TU-144 supersonic airliner. In tests simulating conditions during takeoff, flight, and landing, VAD23 alloy performed very satisfactorily. A weight saving of about 10% could be achieved by substituting VAD23 for AK4-1 alloy (1.9—2.5% copper, 1.4—1.8% magnesium, 1.0—1.5% nickel, 1.1—1.6% iron), the Soviet counterpart of the alloy used in the French-British "Concord" airliner, which has roughly the same flight characteristics as those of TU-144. Satisfactory performance was achieved with VAD23 aged to a coagulation stage (Fig. 1), which produced a very stable structure with relatively low strength but high ductility. With alloy aged to the highest strength level, even higher weight savings could be achieved; however, there is a possibility of embrittlement after 10,000 hr of operation.

Another lithium-containing alloy is the 01420 aluminum-lithium-magnesium alloy, claimed to be a unique Soviet development (VAD23 appears to be a counterpart of a British alloy). The composition of the alloy has not been revealed. It is stated only that it is located in the two-phase $\alpha + Al_2 LiMg$ region of the concentration triangle and that the content of magnesium and lithium was selected to ensure maximum strengthening by heat treatment without lowering corrosion resistance. [A higher lithium content would bring about intensive oxidation of the alloy in air, and a higher content of magnesium would greatly reduce the strengthening effect of heat treatment]. However, it can be

reasonably assumed that the lithium content of 01420 alloy is considerably higher than that of VAD23 alloy, judging from the statement [1] that the density of 01420 is 12% lower than that of Duralumin-type alloys, which averages 2.8 g/cm^2, meaning that the density of 01420 is about 2.46 g/cm^3 compared to 2.72 g/cm^3 for VAD23 alloy [2]. The alloy is also called "light-weight aluminum alloy" [3], a term which is usually not applied to individual aluminum alloys since all of them are considered light alloys.

The 01420 alloy has satisfactory flowability and may be cast into ingots up to 800 mm in diameter. Its solid solution is very stable. After solution annealing, alloy parts can be either water quenched or air cooled. Air cooling results in somewhat (2--3 kg/mm^2) lower strength, but also in lower susceptibility to stress corrosion after aging. The alloy is not ageable at room temperature. For maximum strength, parts are aged at 170°C for 8 to 24 hr, after which they have a tensile strength of 55 kg/mm^2, a yield strength of 50 kg/mm^2, and an elongation of 4—5%. For higher ductility, aging at 120°C for 12 to 48 hr is recommended. In this case the tensile strength (extruded bars) is 48--50 kg/mm^2, the yield strength is 35—40 kg/mm^2, and the elongation is 9—11%. The alloy has an elasticity modulus of 7500 kg/mm^2 [3], which is 8% higher than that of the Duralumin-type alloys [1]. Assuming 01420 and the Duralumin-type alloys are of equal strength, the higher modulus of elasticity and the lower density of the former would yield a weight saving of 12% in tension-stressed members and 15—20% in compression-stressed members [1]. The 01420 alloy is available in the form of extrusions, forgings, sheets and plates. It can be anodized, silver, copper, zinc, and cadmium plated, and spot and seam welded. Fusion welding of VAD23 and 01420 alloys is being studied at the Electric Welding Institute im. Ye. O. Paton.

Interesting results were achieved with sintered aluminum alloys made of granules—fine particles obtained by atomizing molten alloys with a content of alloying elements (up to 10% chromium or iron) significantly higher than the limit of their solid-state solubility in aluminum [1, 4]. Rapid cooling (water quenching) of atomized particles produced highly supersaturated

aluminum-chromium solid solutions containing up to 2% chromium (the limit of solid-state solubility of chromium in aluminum is about 0.8%). No aluminum-iron solid solution could be fixed at the cooling rates used. The granules were compacted and the compacts were extruded at 450 °C into flat bars 10 mm thick and 40 mm wide. At 450 °C the aluminum-chromium solid solution decomposed under precipitation of finely dispersed particles of $CrAl_7$ intermetallic compound. The mechanical properties of the extruded bars were significantly higher than those of conventionally manufactured bars of the same composition. At a chromium content of 10% the alloy had a tensile strength as high as 50 kg/mm^2, but its elongation was low, only 0.4--1.0%. With decreasing chromium content the tensile strength dropped and the elongation increased (Fig. 3). The effect of iron was much less pronounced. With increasing test temperature the tensile strength dropped, the more rapidly the higher the chromium content. However, at temperatures up to 400°C, the tensile strength of alloys with 10% chromium remained higher than that of SAP alloys containing 10% aluminum oxide (Fig. 4) [4].

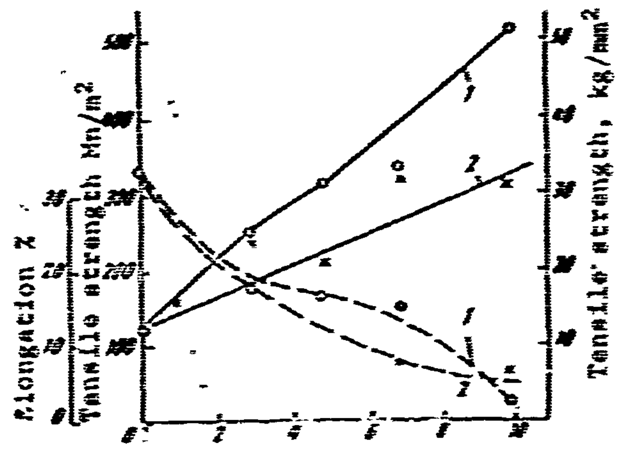

Fig. 3. Composition dependence of tensile strength (solid lines) and elongation (broken lines) of sintered aluminum-chromium (1) and aluminum-iron (2) alloys [4].

An aluminum-magnesium-chromium alloy produced by the above described method combines high strength with high corrosion resistance. In solution-annealed and aged condition it has a tensile strength of 45 kg/mm^2, compared to 36 kg/mm^2 for the strongest aluminum-magnesium alloy. This alloy appears to be a promising shipbuilding material, especially for hydrofoil craft, which are presently built of unalloyed aluminum.

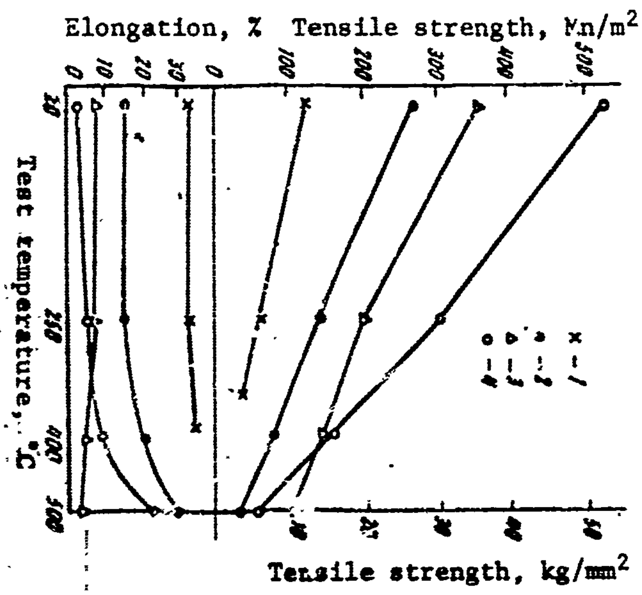

Fig. 4. Temperature dependence of tensile strength and elongation of sintered aluminum alloys containing 1% Al_2O_3 (1), 2% Cr (2), 10% Al_2O_3 (3) and 10% Cr (4). [4]

The SAS-1 alloy, also made from atomized particles, has already found fairly wide application in high-precision instruments. The alloy contains 25% silicon and 5% nickel, has the same density as aluminum, and is distinguished by a low coefficient of thermal expansion, $14.00 \cdot 10^{-6}$, which approaches that of steel. It has a fine structure and a tensile strength of 33 kg/mm^2 at an elongation of 0.5%, compared to 8 kg/mm^2 and 1.3% for a conventionally made alloy which has a coarse-grained structure and a much higher coefficient of thermal expansion [1, 5].

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SURVEYS

SATELLITE OPTICAL TRACKING PROGRAMS

by Daniel W. Michaels

The increased demands for greater accuracy in visual tracking of satellites associated with investigations of the detailed structure of the Earth's gravity field, an expanded space triangulation program, and investigations of irregular density changes in the upper layers of the atmosphere have stimulated the development of more precise satellite tracking cameras and techniques. Much of the advanced tracking instrumentation now being developed in the Soviet bloc originates either in the Soviet Union proper or in East Germany, Czechoslovakia, or Latvia [1].

The standard cameras used at Soviet stations over the past 10 years, the Soviet-manufactured NAFA-3c-25 (d = 100 mm f = 250 mm) and NAFA-MK-75 (d = 210 mm, f = 750 mm) have been modified to meet the more stringent requirements, and new cameras developed in other bloc countries have been tested at Soviet stations. The NAFA-3c uses a Uran-9 objective and has a field of sight of 32 x 52°; its fast shutter is connected to a chronograph. The camera has a reported accuracy of $0'.1$—$0'.2$ in position and $0^{s}.01$ in time. A modified version of the standard NAFA-3c-25 has recently appeared in Soviet, East-bloc, and other cooperating stations as the UFISZ-25-2. UFISZ-25-2 cameras have, for example, been sent to Cuba, Mongolia, Mali, and the United Arab Republic, as well as East Germany, Bulgaria, Rumania, Poland, and Czechoslovakia [2].

In 1968 the Zvenigorod Experimental Station put into operation the first model of a new automatic triaxial satellite camera for photographing faint satellites (up to the 10th magnitude). The Zvenigorod camera, which uses an Astrodar objective designed by Maksutov, has an aperture of 500 mm, a focal length of 740 mm, and a mirror diameter of 1000 mm [3].

Of tracking cameras developed outside the USSR, the East German Zeiss-manufactured 420-500-760 satellite tracking camera, which was first put into operation in the Potsdam

Geodetic Institute in 1965 and which was put into serial production in 1966, represents one of the most advanced instruments for the precise determination of satellite coordinates against a fixed star background. Its technical specifications are: d = 425 mm; f = 760 mm; diameter of main mirror, 500 mm; and plate size, 90 x 120 mm^2. The guide telescope has a magnification of 21.3 x, a field of sight of 3°, and an effective entrance aperture of 76 mm. The instrument can photograph satellites up to the 12th magnitude [4].

Of equal importance is the new automatic AFU-75 camera (d = 210 mm, f = 750 mm), designed by K. K. Lapushka and M. K. Abele (Riga, Latvia), which went into operation in 1967. This camera is especially well suited for recording flashes emitted by active geodetic satellites and can photograph the passage of passive satellites up to the 9th magnitude. In addition to the original model mounted in Riga, this camera has also been put into operation at the Zvenigorod, Uzhgorod, and Pulkovo stations [5].

In 1965 the Czechoslovak Academy of Sciences and Central Administration of Geodesy and Cartography also designed a satellite camera which is now in common use. This instrument, which uses a Telikon objective, has also been sent to the Soviet Union and Poland [6].

The Soviet Union is currently participating in several international satellite tracking programs, some of which are restricted to the Eurasian continent, while others include America and Africa. Among the former are: 1) The visual satellite tracking program for the Ephemeris Service. The coordinator of this program is the Astronomical Council of the Academy of Sciences USSR. The ephemerides are computed at the Soviet computer center "Kosmos," as well as the computer centers of Poland and Czechoslovakia. 2). The INTEROBS program. Base-line visual observations of low satellites are conducted for the purpose of studying short-period changes in atmospheric density. In addition to the Soviet Union, East Germany, Hungary, Poland, Bulgaria, Rumania, and Czechoslovakia participate in this program; Hungary is the coordinator. 3). The satellite photometric observation program, which is coordinated by the Soviet Union and Czechoslovakia. Photometric observations

are made of satellites as they enter the shadow of the Earth for the purpose of studying the aerosol and ozone distribution in the atmosphere as well as the optical properties of the upper atmosphe. e. Special electrophotometric instruments for observing the light reflected from satellites in different parts of the spectrum have been developed in the Astronomical Institute of the Kazakh Academy of Sciences, Alma Ata, and in the Astronomical Institute of the Czechoslovak Academy of Sciences, Onjrejov. 4). Project SPIN. Photometric observations are conducted of satellite rotation for the purpose of studying changes in atmospheric density in connection with changes in solar activity. In addition, the East-bloc states collaborate in the publication of satellite tracking information, the compilation of technical bibliographies, and similar undertakings.

The single most important program extending beyond the Eurasian continent is the synchronous photographic satellite observation program undertaken in connection with problems in space triangulation. The Astronomical Council of the Academy of Sciences USSR is the coordinator of this program. The first space triangulation experiment was conducted in 1961 with the Pulkovo, Nikolayev, Kharkov, and Tashkent stations participating. An accuracy of not more than $\pm$ 80 m was achieved. In May and June of 1963 the first synchronous photograph of Echo-I was obtained when the Potsdam, Prague, Bucharest, and Poznan stations joined in with Soviet stations. In 1965—1966 a space triangulation program was undertaken in an attempt to tie in African stations (Bamako, Mali; Cairo, UAR) with the European network. In 1966—1967 a program of observations of the Pageos satellite was initiated involving the Soviet Union, Bulgaria, Hungary, Italy, Mongolia, Poland, Rumania, Czechoslovakia, Mali, and the United Arab Republic. During these experiments synchronous pairs of observations were made at Cairo-Zvenigorod (3000 km), Cairo-Poznan (3000 km), Cairo-Riga (3500 km), Cairo-Bamako (3500 km), Cairo-Pulkovo (3800 km), Nikolayev-Bamako (5000 km), and Zvenigorod-Bamako (6000 km). Cuba and Mongolia also regularly participate in synchronous photographic observations. Since 1966 the Riga and Uzhgorod stations have been participating in observations of the Geos satellites under a program arranged by the Smithsonian Observatory [7].

At present, the following 16 countries regularly send satellite observational data to the Soviet Union: England, Bulgaria, Hungary, East Germany, Holland, Italy, Cuba, Mongolia, Mali, the United Arab Republic, Poland, Rumania, France, Finland, Czechoslovakia, and Sweden.

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OCEANOGRAPHIC MATERIAL AT WORLD DATA CENTER "B"

SUMMARY: This survey describes the data collected and stored at World Data Center "B" in the Soviet Union up to 1 December 1965. It is believed to be the only data of this nature ever published in the Soviet Union.

The contacts established by World Data Center "B" (WDC "B") are wide and diversified. The closest and the most fruitful cooperation in the field of oceanography has been established with World Data Center "A" in the United States, with the national centers in Canada, Australia, and Japan, and with various international organizations (i. e. International Council for the Exploration of the Sea, etc.).

An enormous amount of oceanographic data is being stored at WDC "B." In respect to the number of cruises and station observations all of the data can be divided into two approximately equal parts (see Table 1): the data prior to 1959 (677 cruises and 33,815 stations) and the data for the period 1960—1964 (573 cruises and 27,028 stations). Data from 34 countries, obtained by 400 ships during 1250 cruises, have been collected at WDC "B" during these years. The number of investigations performed in the oceans is not equally distributed. The largest number of stations represented at WDC "B" was taken in the Atlantic and the Pacific Oceans; the smallest number — in the Arctic and the Antarctic. Most of the observations carried out by various countries were made in the coastal areas; however, the larger countries (USA, USSR, France, Japan, Canada, England) also conducted observations in different parts of the oceans.

During the last 5 years considerable attention has been focused on the investigation of the Pacific and Indian Oceans. There are now twice as many stations in these two areas as there were prior to 1959. In general, the investigations performed during IGY and during the last few years have encompassed the entire territory of the World Ocean.

Table 1. The data received by WDC "B"

	Before 1960	1960—1964	Total
Number of ships........	298	190 (98 of this number did not take part in the IGY)	488
Number of cruises......	677	573	1,250
Number of lighthouses..	55	9 (2 did not take part in the IGY)	64
Number of permanent stations............	164	247 (153 did not take part in the (IGY)	411
Number of oceanographic stations............	33,915	27,088	61,003
Types of investigations		Number of measurements	
Bathythermograms.......	21,984	23,433	45,417
Currents			
Deep measurements....	1,392	223	1,615
Surface measurements.	11,539	3,563	15,102
Sediments			
Bottom...............	1,587	355	1,942
Subbottom............	1,137	288	1,425
Relief*...............	43	16	59
Biology			
Plankton.............	11,028	4,529	15,557
Pigment content......	1,064	1,195	2,259
Primary production...	1,565	1,691	3,256
Icthyology, etc......	981	1,043	2,024

* Number of cruises during which the relief was investigated.

Of considerable importance are the data collected by the International Indian Ocean Program, the joint international investigations of the tropical and northern parts of the Atlantic Ocean (Northwestland) organized by the ICES, and the "Gibraltar" program. The simultaneous participation of ships and specialists from different countries made it possible to carry out an extensive number of investigations and to check out various observation techniques. In addition, such international expeditions attracted new members; most countries cooperating in

the field of oceanography became participants (see Table 2).

Table 2. International program.

Program	Member nations	Number of completed cruises	Program	Member nations	Number of completed cruises
Joint international investigations of the tropical part of the Atlantic Ocean	Argentina.....	2	International Indian-Ocean program	Australia.....	23
	Brazil........	3		Great Britain.	2
	Ghana.........	1		Indonesia.....	4
	Spain.........	2		Portugal......	2
	Nigeria.......	2		USSR..........	4
	Ivory Coast Republic....	3		USA...........	15
				France........	6
	Republic of the Congo (Brazzaville).	2		South African Republic....	6
				Japan.........	8
	USSR..........	7			
	USA...........	9			
Total:	9 nations	31	Total:	9 nations	70

Oceanographic data collected by WDC "B" are obtained not only from scientific cruises but also from observations made at permanently operating coastal and high-sea stations. These observations have been conducted by several countries (see Table 3), with the USA, Canada, Denmark, Finland, Norway, the Netherlands, France, and Japan being the most active participants. Observations made at lighthouses belonging to Denmark, the USA, the Netherlands, Ireland, the FRG, Sweden, and Belgium are also collected at WDC "B." Data from permanent stations and lighthouses are in the form of daily, monthly, or occasional measurements of oceanographic and meteorological parameters. Some nations, such as France, the Netherlands, Australia, Japan, the USA, Denmark, and Great Britain contribute data on surface observations. The amount of data contributed by cooperating nations varies (see Table 3). About 55,000 out of 61.000 measurements collected at oceanographic stations

Table 3. General quantitative characteristics of data received by WDC "B"

Nations	Ships	Cruises	Lighthouses	Permanent stations	Oceanographic stations	Number of measurements: Bathythermograms	Currents: Surface	Currents: Deep	Relief	Sediments: Bottom	Sediments: Subbottom	Biology: Plankton	Biology: Pigment content	Biology: Primary production	Biology: Ichthyology, etc.
Australia															
Before 1960	28	80		20	1,951				2			225	346	280	+
1960—1964	15	42		11	1,351						5	590	752	907	+
Total	43	122		31	3,302				3		5	815	1,098	1,187	+
Argentina															
Before 1960	9	19		12	246				1			233			
1960—1964	4	19			466	865						148		50	
Total	13	38		12	712	865			1			381		50	
Belgium															
Before 1960			2												
1960—1964			2												
Total			4												
Brazil															
Before 1960	1	5			153							110	36		
1960—1964	4	5			240	26						107			
Total	5	10			393	26						217	36		
Great Britain															
Before 1960	25	53	4	12	4,615		75								
1960—1964	7	16		1	443		95 4 maps		1						
Total	32	69	4	13	5,058		170 4 maps		1						
Ghana															
Before 1960															
1960—1964	1	1			7	12									
Total	1	1			7	12									
Denmark															
Before 1960	6	14	14	21	1,176		12								
1960—1964	1	2			106										
Total	7	16	14	21	1,282		12								

Table 3 (continued)

Nations	Ships	Cruises	Lighthouses	Permanent stations	Oceanographic stations	Bathythermograms	Currents: Surface	Currents: Deep	Relief	Sediments: Bottom	Sediments: Subbottom	Biology: Plankton	Biology: Pigment content	Biology: Primary production	Biology: Ichthyology, etc.
India															
Before 1960					34	6									
1960—1964	1	2													
Total	1	2			34	6									
Indonesia															
Before 1960	1	3			138	8									
1960—1964	1	4			43										
Total	2	7			181	8									
Ireland															
Before 1960			1												
1960—1964			1												
Total			[illegible]												
Iceland															
Before 1960	4	6			557	168									
1960—1964	2	5			274										
Total	6	11			831	168									
Spain															
Before 1960															
1960—1964	2	3			113	187									
Total	2	3			113	187									
Italy															
Before 1960	10	17			752										
1960—1964	1	1			67										
Total	11	18			819										
Canada															
Before 1960	9	18		7	1,227	5,066	1,803	3				539	12	9	
1960—1964	23	81	2	17	4,739	9,063	246	10				12	48	12	
Total	32	99	2	24	5,966	14,129	2,049	13				551	60	21	
Colombia															
Before 1960	2	2				316									
1960—1964															
Total	2	2				316									

Table 3 (continued)

Nations	Ships	Cruises	Lighthouses	Permanent stations	Oceanographic stations	Number of measurements: Bathythermograms	Currents: Surface	Currents: Deep	Relief	Sediments: Bottom	Sediments: Subbottom	Biology: Plankton	Biology: Pigment content	Biology: Primary production	Ichthyology, etc.
Republic of the Congo (Brazzaville)															
Before 1960															
1960—1964	1	3			94	156						31		22	
Total	1	3			94	156						31		22	
Netherlands															
Before 1960	3	4	4	5	416	179									
1960—1964	6	23	4	5	1,951	466									
Total	9	27	8	10	2,367	645									
New Zealand															
Before 1960	3	2			75									2	
1960—1964															
Total	3	2			75									2	
Norway															
Before 1960	8	21		1	3,142			26	2						
1960—1964	5	13		1	315			25	1						
Total	13	34		2	3,457			51	3						
Pakistan															
Before 1960	1	2				65									
1960—1964															
Total	1	2				65									
Portugal															
Before 1960															
1960—1964	1	2			90										
Total	1	2			90										
Poland															
Before 1960	3	17			277										
1960—1964															
Total	3	17			277										

Table 3 (continued)

Nations	Ships	Cruises	Lighthouses	Permanent stations	Oceanographic stations	Number of measurements									
						Bathythermograms	Currents		Relief	Sediments		Biology			
							Surface	Deep		Bottom	Subbottom	Plankton	Pigment content	Primary production	Ichthyology, etc.
USSR															
Before 1960	31	65		2	3,941	1,501	691	718	19	871	904	2,183		531	263
1960—1964	22	77			3,387	2,985	33	164	7	107	156	546		88	250
Total	53	142		2	7,328	4,486	724	882	26	978	1,060	2,729		619	513
USA															
Before 1960	67	203	5	38	9,668	9,768	2,741	98	16	259	683	5,296	567	618	473
1960—1964	45	163		179	8,870	6,279	335	7	4	108	177	697	314	511	307
Total	112	366	5	217	18,538	16,047	3,076	105	20	367	860	5,993	881	1,129	780
FRG															
Before 1960	2	7	8		999	740			2						
1960—1964	2	6			306			3							
Total	4	13	8		1,305	740		3	2						
Finland															
Before 1960	1	5	6	32	260	148	1,200	6							
1960—1964	1	1		32	107										
Total	2	6	6	64	367	148	1,200	6							
France															
Before 1960	43	66		7	1,680	96	1,130	15				85	103	125	
1960—1964	28	44		1	1,158	207	113 & maps	13	3	54		17	10		
Total	71	110		8	2,838	303	1,243 & maps	28	3	54		102	113	125	
Chile															
Before 1960	2	1		2		52									
1960—1964															
Total	2	1		2		52									
Sweden															
Before 1960	3	5	11		246		700	11							
1960—1964															
Total	3	5	11		246		700	11							

Table 3 (continued)

Nations	Ships	Cruises	Lighthouses	Permanent stations	Oceanographic stations	Number of measurements: Bathythermograms	Currents: Surface	Currents: Deep	Relief	Sediments: Bottom	Sediments: Subbottom	Biology: Plankton	Biology: Pigment content	Biology: Primary production	Biology: Ichthyology, etc.
Yugoslavia															
Before 1960	2	6			102		347	353							
1960—1964															
Total	2	6			102		347	353							
UAR															
Before 1960	3	8			609							608			
1960—1964	3	7			290							45		87	
Total	6	15			899							653		87	
Japan															
Before 1960	30	46		5	1,651	3,871	2,840	162	1	7		1,749			245
1969—1964	12	50			2,576	3,024	2,741	1		19		2,301	71		486
Total	42	96		5	4,227	6,895	5,581	163	1	26		4,050	71		731
Nigeria															
Before 1960															
1960—1964	2	2			26	72						14		7	
Total	2	2			26	[illegible]						14		7	
Ivory Coast Republic															
Before 1960															
1960—1964	1	3			47	81					17	21		7	
Total	1	3			47	81					17	21		7	
General total															
Before 1960	297	675	55	164	33,915	21,984	11,539	1,392	43	1,137	1,587	11,028	1,064	1,565	981
1960—1964	191*	575	9**	247***	27,088	23,433	3,563	223	16	288	355	4,529	1,195	1,691	1,043
Total: 34 nations	488	1,250	64	411	61,003	45,417	15,102	1,615	59	1,425	1,942	15,557	2,259	3,256	2,024

* Of this number, 98 did not take part in the IGY.
** Of this number, 2 did not take part in the IGY.
*** Of this number, 153 did not take part in the IGY.

were made by oceanographers of the USA, Canada, the USSR, Great Britain, Japan, Australia, and France. The contributions of these countries in respect to the number of stations and the scope of the program vary. The multidiscipline investigations conducted by the USSR, the USA, Japan, the FRG, Canada, Norway, Australia, and France have had the highest scientific value. They included hydrochemical and hydrological stations and bathythermographic, geological, biological, meteorological, surface, and current observations (see Table 3). The data from hydrological and hydrochemical stations and bathythermograph recordings make up the largest part of the material collected.

The observations performed at individual oceanographic stations vary for different countries and cruises. Primarily, the program of such observations during cruises includes the collection of data on the temperature, salinity (sometimes chloride content), density, hydrogen ion concentration, alkalinity, the content of O, N, P, Si, C, and their compounds, as well as the computation of data from the anomaly of dynamic heights, anomaly of specific volume, potential temperature, potential energy, and sound velocity. The methods used in determining these elements vary considerably, and in most cases their description is added to the data. Such series of observations are conducted by the USSR, the USA, Canada, France, the FRG, Australia, Norway and other countries; these comprise 50% of all data from oceanographic stations. The other half of the data includes observations of only the temperature, salinity, density, and oxygen. The data are given for both the actual and standard levels, with station depths varying between 200 and 5000—6000 m; occasionally station depths exceed 6000 m.

Bathythermographic observations at WDC "B" consist primarily of photographic copies of bathythermograms; however, some data are given in tabular form (i.e. data obtained by the USSR, the Netherlands, and Japan). The bathythermograph records supplied by countries other than the USSR are accompanied by data on surface temperature, salinity, and by data from meteorological observations. Although the number of such investigations is very large, the contributions made by different countries on the temperature distribution obtained by means of bathythermographs also vary (see Tables 1 and 3).

The small amount of material on currents does not decrease its great value. The following relatively few countries are contributing data on the investigation of currents: the USSR, the USA, Japan, Yugoslavia, France, Norway, Canada, Sweden, Denmark, Finland, Great Britain, and the FRG. These countries have made different contributions to the investigation of currents (see Table 3). WDC "B" has collected data from 1615 deep stations and 15,102 surface-current measurements. In addition, WDC "B" has maps of surface currents from almost 100 cruises off the coast of California. The greatest number of deep-current stations have been occupied by the USSR in the Baltic Sea, the northeastern Atlantic, the northern part of the Pacific, and in the waters of the Antarctic. Seven hundred deep- and surface-current stations have been occupied by Yugoslavia in the Adriatic Sea. Japan has made 5000 measurements of deep and surface currents in the Sea of Okhotsk, the Sea of Japan and in the northwestern part of the Pacific Ocean. The United States has made 3000 deep and surface measurements covering the Gulf of Mexico, the North Atlantic, and the Pacific Ocean — the seacoasts of Central America and California. The rest of the measurements were made by France (Strait of Gibraltar, the Gulf of Guinea, and Mozambique Channel); Norway (Faeroe-Shetland Channel and the northeastern Atlantic at depths of up to 1000 m); Canada (North Pacific); Finland and Sweden (in the Baltic Sea, where lighthouses have been conducting daily observations up to depths of 40 m over the past several years); Denmark (daily surface observations at 12 lighthouses); and by Great Britain and the FRG (see Table 3). All these observations are conducted using various methods and instruments. Data from deep measurements stored at WDC "B" have been obtained using different types of current meters. The Ekman, Price, and other current meters are used abroad. Floats and bottles have been used to collect surface-current data. A considerable amount of data on currents has been gathered using geomagnetic electrokinetographs, particularly by the United States and Japan.

Exceedingly valuable geological data are stored at WDC "B" (see Tables 1 and 3). The development of science and technology has led to the possibility of applying new methods for the study of the relief of ocean floors and bottom sediments. The use of echo sounders made it possible to make continuous recordings of relief and has led to several important discoveries.

The utilization of geological corers of different design, seismic sounding, etc., makes it possible to investigate the bottom sediments and their distribution.

The data at WDC "B" include material from 59 cruises during which the relief of the ocean bottom was investigated (see Table 3). The data consist primarily of ocean floor profiles (observations conducted by the *Vityaz'*, *M. Lomonosov*, *Crawford*, *Umitaka Maru*, *Anton Dorn*, and *Gauss*), topographic maps (*Vema*), and tables (*Ekvator* and *Helland-Hansen*).

The investigations of the bottom sediments are represented primarily by the data collected by the USSR and the USA and, also, by France, Japan, Australia, and the Ivory Coast (see Table 3). Information on bottom sediments consists of bottom and sub-bottom samples obtained at 3300 stations. The sub-bottom samples were obtained by corers. The investigations conducted by *Vityaz'* (Pacific and Indian Oceans) and by the "Deepfreeze" American expeditions (Antarctic waters) are especially valuable. Trawling and dredging devices were mainly used for the study of bottom deposits which comprise 40% of the total number of samples. The material at WDC "B" includes a large amount of biological data—the result of more than 2000 biological stations (see Table 1). It consists of material on plankton (about 70%), primary production, pigment content, ichthyological investigations, sea birds, etc. Although several countries participated in these investigations, the USA, USSR, Canada, and especially Australia and Japan have made the greatest contribution (see Table 3). The investigations conducted by Australia are characterized by their wide scope—the study of pigment content, primary production, and ichthyology. The Japanese data consist of detailed ichthyological investigations conducted during almost every cruise. In addition to the above-given oceanographic data, almost every expedition collects meteorological data at oceanographic stations and certain other surface observations. The meteorological observations include data on wind (speed and direction), weather, cloudiness, precipitation, barometric pressure, visibility, humidity, temperature (dry and wet thermometer), wave height, and swell.

Some data on wave height were obtained from instrumented observations (wave records, USSR); however, most of the data are from visual observation (height and period of waves). WDC "B" also has some material on the color and transparency of the seas. Several cruises by ships from Finland, Japan, Canada, and the USA were devoted to the investigation of ice. The ice observations are included in many programs, such as the International Ice Patrol Expedition.

The data collected by the expeditions are sent to WDC "B" in various forms. Primarily, the data consist of typographic and rotoprint editions, with the remainder consisting of loose pages in the form of tables. Carefully prepared and edited reports containing data on cruises, maps, description of methods, etc., are sent by the following organizations in the USA: Special Scientific Report Fisheries; Woods Hole Oceanographic Institution; the Oceanographic Branch of the U. S. Navy; Washington University; Scripps Institution of Oceanography; and several other scientific organizations. Some the other material includes the *Manuscript Report Series*, p hed in Canada, and various publications of the National Canadian Oceanographic Center; *Cahiers Oceanographiques*, published in France; Australian reports of the Department of Fishing Industry and Oceanography of the Scientific and Industrial Studies Administration of Australia; the reports of the Meteorological Department of Japan entitled *The Results of Marine Meteorological and Oceanographic Observations and Exploratory Fishing*, published by Hokkaido University; journals such as *Fisheries of Tokyo University*; and published data sent by Argentina, the FRG, Finland, and Denmark. WDC "B" also receives material from international organizations, such as ICES and ICNAF, publications of various national oceanographic centers, and numerous other publications.

The center contains extremely valuable data, but the analysis of national programs shows that not all of the data obtained during the investigation of the World Ocean has been sent to WDC "B." A comparison of the programs of various countries for the period 1960—1965 with the data sent to WDC "B" (similar analysis was made also at WDC "A") shows that not more than 50% of the data obtained was sent to the center. However, some

nations (Poland, Sweden) did not submit any data either to WDC "A" or WDC "B," and some nations (Great Britain, the FRG) submitted not more than 5% of their data to WDC "B."

In spite of this, WDC "B" contains an enormous amount of material, indicating that close cooperation in the field of oceanographic investigation of the World Ocean is extremely fruitful and useful. [VG, CS]

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NOTES

EQUIPMENT FOR MEASURING THE LEVEL OF COSMIC RADIO EMISSION IN THE DECAMETER BAND

Since 1959 the Gor'kiy Scientific-Research Institute of Radiophysics has used radioastronomical methods to measure the absorption of decameter-band radio waves in the ionosphere. In this waveband, measurements have been made of the radio emission spectra of galactic and powerful discrete sources, and investigations have been carried out of fluctuations in the emission intensity of the discrete sources due to nonuniformities of the electron concentration in the ionosphere.

A description is given in [1] of the multichannel radio equipment used for the reception and recording of galactic radio emission. Each receiver channel consisted of an antenna, an antenna block for the calibration of the equipment, an R-250M receiver, an output unit, and a recording device. The measurements were performed in the 6—25-MHz frequency range, with the majority of them being conducted at 6, 9, 13, 18, and 25 MHz and at frequencies of 30, 40, and 54 MHz by using a frequency converter at the receiver input.

Cophased antenna arrays consisting of six full-wave dipoles, located at a height of 0.2 λ (where λ is the resonant wavelength of each antenna) above the ground, comprised the individual channel antennas. These antennas had a directive gain of 43 and a sufficiently narrow passband equal to about 0.01 from the resonant frequency at an SWR < 1.2. The maximum of the antenna directional pattern was directed toward the zenith. The antenna array and connecting lines were made with PAMG-6 cable and were suspended from 12 masts.

To decrease ground losses, wire screens (mesh size, 0.035 λ) were provided for the antennas operating at the higher frequencies. Those operating at 9 and 6 MHz were not provided with screens, because at these frequencies the electrical properties of the moist soil (the measurements were conducted during the fall) were close to the electrical properties of the metal. The calculated efficiency of screened antennas was about 0.98 [2].

Periodic calibration of the receiver amplifier was performed by the antenna block, which contained a switch, a 2D2S diode noise generator, gas-discharge noise generators, and a circuit for generating time markers. The 2D2S noise generator was used as a reference for measuring the noise figure and amplitude characteristics of the receiver and for calibrating the gas-discharge noise generators.

The R-250 receiver amplified and filtered the signal. One of its outstanding characteristics was its low noise figure (3—5).

In the output unit the signal was square-law-detected and the impulse noise was limited. The detection was performed after doubling the signal frequency in order to ensure adequate linearity of the amplitude characteristics for large signal outputs. The detected signal was then integrated (integration time constants, 0.1 or 1 sec) and fed to an impulse noise limiter (rise time constant, 10 or 100 sec) before being recorded.

The operating frequency bandwidth of each channel was determined basically by the bandwidth of the R-250 receiver and could be varied from 1 to 14 kHz. A bandwidth of 1—3 kHz was used for measurements below 20 MHz, and a bandwidth of 6—12 kHz was used for measurements above 20 MHz.

The amplitude characteristics of the output unit were linear to within (+1)—(-2)%. Recording of the output signal could be performed with or without limiting the impulse noise. Other characteristics of an individual receiving channel were: power consumption, not more than 350 w; diurnal variation of the gain (caused by variations in the ambient temperature), not more than 10%; and maximum error in long-term measurements of cosmic radio emission (without taking into account changes in the antenna parameters), 5%. [IV]

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PERSONALITIES

DR. JANUSZ GROSZKOWSKI, PRESIDENT OF THE POLISH ACADEMY OF SCIENCES

Janusz Groszkowski was born in 1898 and graduated in electrical engineering from Warsaw Technical University in 1922. In 1928 he obtained the degree of Doctor of Technical Sciences at the same university.

In 1922 Groszkowski began teaching radio engineering in the Electrical Engineering Department at Warsaw Technical University. He later became head of the Chair of Radio Engineering there. Presently he is the head of the High Vacuum Chair in the Electronics Department.

Groszkowski's name has been prominent throughout the history of Polish electronics. His role, both in the scientific and organizational aspects of his field, has been that of a pioneer and he is therefore regarded as the Father of Polish Electronics.

Groszkowski appeared on the international scene in 1927, when he published in Polish and French a monograph entitled *Cathode Tubes and Their Application in Radio Engineering*, one of the world's first major studies on the development of electron tubes. For many years this monograph served as a basic textbook in colleges in Poland and France.

Groszkowski's most important contributions to electronics are contained in a series of papers dealing with the theory of nonlinear oscillations and frequency stabilization. These papers were published in Poland in 1932. They appeared in the United States in the *Proceedings of IRE* in 1933 under the title *Frequency Variations and the Harmonic Content in Oscillating Circuits. Constant Frequency Oscillators*. In these papers, Groszkowski 1) demonstrated that the nonlinear theory of oscillations presents the only correct picture of the phenomena occurring in various types of oscillators, and 2) presented a simple method, known as the "Groszkowski Harmonic Method," for analyzing these phenomena.

As time passed, Professor Groszkowski developed and expanded his theory. In 1938 he published *The Fundamentals of*

Electrical Frequency Stabilization, and in 1947 *Frequency Generation and Stabilization*. An application of the harmonic method to relaxation oscillations was presented in his paper on *Frequency of Relaxation Systems*, and another use of this method for transients was analyzed in the paper, *Extension of the Principle of the Reactive Power Balance of Harmonics to Continous-Spectra Systems*.

A paper *On the Temperature Coefficient of Coil Inductance*, published in Great Britian in 1935 and in the United States in 1937, was closely related to problems of frequency stabilization. Groszkowski proved the relationship between the temperature variations in inductance and the skin effect.

Groszkowski summarized his work in these areas in two monographs: *The Generation of Electric Oscillations*, and *Frequency of Self-Oscillations*. The latter was published in 1964 in Great Britian by the Pergamon Press. Several of Dr. Groszkowski's works have been translated into Chinese, English, French, Rumanian, and Russian.

In the history of the 50 years of radio-electronics published on the occasion of the 50th anniversary of the Institute of Radio Engineers in the United States, Groszkowski's name was one of seven mentioned in the section on the theory of electrical nonlinear oscillations. Groszkowski became a Fellow of the IEEE in 1965.

Another of Groszkowski's major interests has been industrial electronics research. Here his attention has centered mostly on vacuum electronics. During the period between 1935 and 1939, Groszkowski concentrated his research on microwave tubes and on the development of new methods for measuring vacuums. His monograph *High-Vacuum Technology*, first published in 1948, has gone through three Polish editions and one Russian edition.

His work in high-vacuum technique and measurements at pressures below 10^{-10} torr resulted in the development of an ionization gauge. French patent rights for this gauge were purchased in 1967, and American rights were assigned in 1968.

In the realm of electrical measurements, Gr wski developed a compensation method for investigating the . ribution of electric fields (1927), which became a starting point for many works on high-voltage insulating systems; he also applied photocells for efficiency measurements of tube oscillators (1931).

During the German occupation of Poland, Groszkowski helped the Allied cause by unraveling the secrets of the electronic equipment of the German V-2 rocket. His findings were utilized in preparing for the defense of Britain.

In the postwar period, Groszkowski initiated scientific research in television and semiconductors. Basic work in the development of semiconductor devices, particularly transistors, was done under his direction. This work led to the development of large-scale transistor production in Poland.

Groszkowski was instrumental in establishing (1928) the Institute of Radio Engineering, which later became the State Institute of Telecommunications. He served as President of this institute until 1939, and then again after the war, until 1950. The Industrial Institute of Telecommunications, the Institute of Electronic Technology, the Industrial Institute of Electronics, the Communications Institute, and the Institute of Telemechanics owe much to Groszkowski's initiative and organizational efforts. He also organized the Electronics Division of the Institute of Basic Technical Problems of the Polish Academy of Sciences, and was appointed its first Director in 1951.

In 1920, Groszkowski initiated the establishment of the *Radio Engineering Review*, and after the War he founded and edited the *Archives of Electrical Engineering*. He later edited the Engineering Series of the *Foreign Bulletin of the Polish Academy of Sciences*. Groszkowski is the author of some 200 articles and monographs published in Poland and abroad.

In 1951, Groszkowski became a member of the Polish Academy of Sciences. He served as the Academy's Vice President from 1956 to 1962 and became its President in 1962. He heads several editorial boards of scientific journals and belongs to a number of foreign scientific bodies. He also holds two honorary doctoral degrees. [JP]

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BOOK REVIEWS

ROCKET ENGINES

Mel'kumov, T. M., N. I. Melik-Pashayev, P. G. Chistyakov, and A. G. Shiukov. Raketnyye dvigateli (Rocket engines). Moskva, Izd-vo Mashinostroyeniye, 1968. 511 p.

In recent years the Soviets have published a number of monographs dealing with various specific problems of rocket propulsion technology, e.g., combustion processes, performance characteristics, basic rocket theory and design principles, etc. However, t recently published monograph edited by Professor T. L. Mel'kumov is the first attempt to present a comprehensive coverage of this broad subject. The monograph presents fundamentals of the theory and design of solid and liquid fuel rocket engines. Intended for a wide range of readers, including engineers and postgraduate students in aviation schools, the book is based on both Soviet and non-Soviet literature (there are 60 references cited, 16 of which appear to be of non-Soviet origin). The authors present a general theoretical treatment of rocket propulsion technology problems, with illustrations limited to schematic drawings. There are no photographs or references to any specific engines or components. In covering the problem of rocket control, Mel'kumov and colleagues present a detailed analysis of rocket engine dynamics. They also place special emphasis on vibration analysis and the structural integrity of rocket engine components.

The book is divided into two parts, part one dealing with the theory of solid- and liquid-fuel rocket engines, and part two, with construction and design calculations of individual rocket engine components, and basic information on control systems and automatic control of rocket engines.

The first two chapters are devoted to the basic engine cycles, parameters, and characteristics of rocket engines and to the calculation of engine efficiency. Chapter three presents basic properties of liquid propellants. Processes taking place in combustion chambers of liquid- and solid-fuel rocket engines, the

problem of liquid-fuel mixing and atomization, and factors affecting the performance stability of rocket engines are covered in Chapters 4—6.

Chapters 7, 8, and 9 are devoted to nozzle flow, thermodynamic calculations, and performance characteristics of rocket engines. Heat transfer and chamber cooling are covered in Chapter 10, while Chapter 11 deals with the problem of using nuclear energy for rocket propulsion. The fundamentals of nuclear reactor theory, diagrams of possible nuclear rocket engines, and a comparison of chemical and nuclear rocket performance characteristics are presented. Structural elements of thrust chamber assemblies and methods of calculating their strength and vibrations are presented in Chapters 12 and 13. The assembly and strength calculation of various elements of turbopump units for liquid rocket engines, and the elements of fuel feed systems, including gas generators, valves, piping and pressure reducers, are discussed in Chapters 15 and 16. The concluding three chapters are devoted to automatic control systems and automatic control of liquid rocket engines. In particular, the structural elements, strength calculation, and control of solid-fuel rocket motors are discussed. Chapters 1, 2, 5, 6, and 11 were written by T. M. Mel'kumov; Chapters 3, 4, 7, and 10, by N. I. Melik-Pashayev; Chapters 12, 13, 14, 15, and 18, by A. G. Shiukov; and Chapters 16 and 17, by P. G. Chistyakov. [AS]

LIGHT SCATTERING IN THE ATMOSPHERE

Ivanov, A. I., G. Sh. Livshits, V. Ye. Pavlov, B. T. Tashenov, and Ya. A. Teyfel'. Rasseyaniye sveta v atmosfere (Light scattering in the atmosphere). Part 2. Alma-Ata, Izd-vo "Nauka", 1968. 116 p.

This monograph on direct and inverse problems of light scattering in the terrestrial atmosphere contains the results of spectrophotometric investigations of the brightness and polarization of the day sky, scattering functions, and other optical parameters of the atmosphere conducted in the Department of Optics of the Astrophysical Institute of the Kazakh Academy of Sciences. The monograph complements an earlier (1965) work, *Rasseyaniye sveta v atmosfere* (Light scattering in the atmosphere), by G. Sh. Livshits. Whereas Part I dealt chiefly with the results of investigations of the direct problem, the determination of the radiation field of the real atmosphere, Part 2 attempts a more rigorous solution of the direct problem and investigates the possibility of solving the inverse problem, the d[illegible]ermination of the aerosol size spectrum from observations of the intensity and polarization of scattered light.

Chapter [illegible]veys works on sky brightness, comparing the results of [illegible] observations with theory. Methods of computing sky brig[illegible]d polarization taking into account multiple scattering an[illegible]e aerosol microstructures are presented. Chapter II discuss[illegible]s the variations and interrelations and the angular and spec[illegible] dependences of scattering functions. Investigations of t[illegible]cility and transparency of the atmosphere, scattering function[illegible], and optical thicknesses (total, aerosol, haze) are summarized. Pure absorption in aerosols is investigated, and on the basis of established properties of the aerosol scattering function a formula is developed relating several optical parameters of the terrestrial atmosphere. Chapter III examines the inverse problem — the determination of the aerosol spectrum on the basis of optical sky observations. The results of investigations of the spectrum of the larger aerosol fraction

are given, and the role of Aitken particles assessed. Deviations from theoretical aerosol models with the Junge size distribution are indicated.

The monograph is based on 153 references, most of which are Soviet, German, and American, including AFCRL-65-710 (Special Report) and USASRDL Fort Monmouth Tech. Rept. 2247. The monograph was under the overall editorship of G. Sh. Livshits, who gives special thanks to G. V. Rozenberg for reviewing it. [DM]